5022.1TA

BELOW-THE-HOOK LIFTING DEVICE
Engineering Note Cover Page for MD-ENG-064

Lifting Device Numbers:

FNAL Site No/ ________________ (If applicable) Div. Specific No. **152** (If applicable) Asset No. ________________ (If applicable)

ASME B30.20 Group: (check one)

[X] Group I Structural and Mechanical Lifting Devices
[ ] Group II Vacuum Lifting Devices
[ ] Group III Magnets, Close Proximity Operated
[ ] Group IV Magnets, Remote Operated

Device Name or Description **Lifting Bracket for SM3 and VM Inner Yokes**

Device was (check all applicable)

[ ] Purchased from a Commercial Lifting Device Manufacturer. Mfg Name ________________
[**X**] Designed and Built at Fermilab **Eng. Drawing: MD - 407783**
[ ] Designed by Fermilab and Built by a Vendor. Assy drawing number ________________
[ ] Provided by a User or other Laboratory
[ ] Other: Describe ________________

Engineering Note Prepared by **Edward Chi** Date **Dec. 29, 2004**

Engineering Note Reviewed by **Dave Pushka** Date **Jan. 05, 2005**

Lifting Device Data:

Capacity **59,680 lbs**.

Fixture Weight **320 lbs**.

Service: [X] normal [ ] heavy [ ] severe (refer to B30.20 for definitions)

Duty Cycle _______ 8, 16 or 24 hour rating (applicable to groups III, and IV)

Inspections Frequency ________________

Rated Load Test by FNAL (if applicable) Date ________________ Load ________________

[ ] Check if Load Test was by Vendor and attach the certificate

Satisfactory Load Test Witnessed by: ________________

Signature (of Load Test Witness) ________________

Notes or Special Information:

The load test procedures and the load test also should make as part of the note.

Fermilab

Particle Physics Division
Mechanical Department Engineering Note

Number: MD-ENG- 064 Date: December 29, 2004

Project Internal Reference:

Project: BTeV, SMTF

Title: Lifting Bracket for SM3 and VM Inner Yokes

Author(s): Edward Chi Dec. 29, 2004

Reviewer(s): David Pushka Jan. 05, 2005

Key Words: Bracket, lifting, bolt, allowable stress, weld, tensile, shear

Abstract Summary: The lifting bracket is specially designed for lifting and moving the inner yokes and other applicable yokes and blocks during SM3 disassembly in Meson east building and VM assembly in C0 building. The working stresses of bracket and the bolt, the welding sizes subject to applying load have been studied per the related specification and codes.

Applicable Codes:

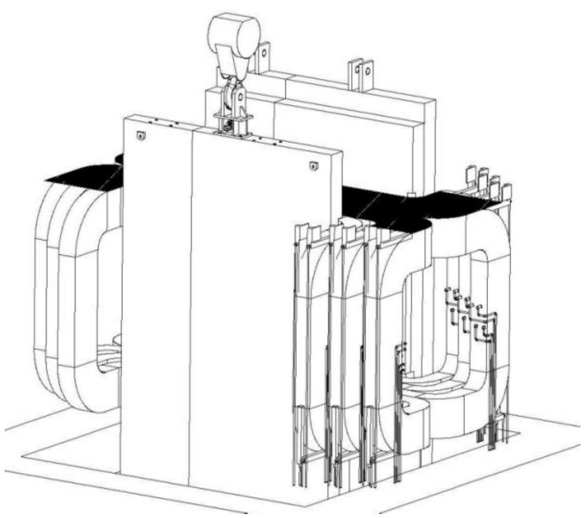
"Allowable Stress Design", AISC, 9th edition
"Below-the-Hook Lifting Devices", ASME B30.20
#5022, ES&H Manual, FermiLab.
"Structural Welding Code-Steel", AWS D1.1-90
"Aluminum Design manual" by The Aluminum Association, Inc. 6th edition.

Design the lifting bracket for moving Inner- blocks and other blocks of SM3 in Meson East

Design Criteria and Assumptions:

Total design load:
P_v = 60,000 lbs = 30 tons, when the load is applying as shown on figures 1 & 2.
P_h= 38,000 lbs = 19 tons, when the load is applying as shown on figure 4.
All materials for bracket: ASTM A36: F_u = 58 ksi, F_y = 36 ksi
All bolt materials: ASTM A325, F_u = 105 ksi
All weld materials are E70, where F_u = 70 ksi

This bracket is specially designed for lifting & moving the sm3 yokes, plates at Meson east, where the crane hook has to directly connect to the lifting bracket because of the height limitation of the crane. Also it is for lifting and moving Vertex Magnet yokes, pole inserts and plates in BTeV CO building.



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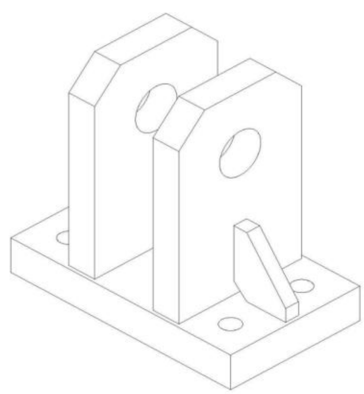

(II)

Figure 1. The isometric view of the lifting bracket for SM3 & its application

Part I of figure 1 is an isometric view to show one of the applications, where 4 bolts will be bolted to the yoke of sm3 magnet, the crane hook will lifting the yoke through 3" diameter lifting pin.
Part II of figure 1 is an isometric view of the lifting bracket.

1.Find out the working stresses when the lifting force P_v applying vertically.

Figure 2 is simulating the force distribution of the bracket when force applying vertically through lifting pin.

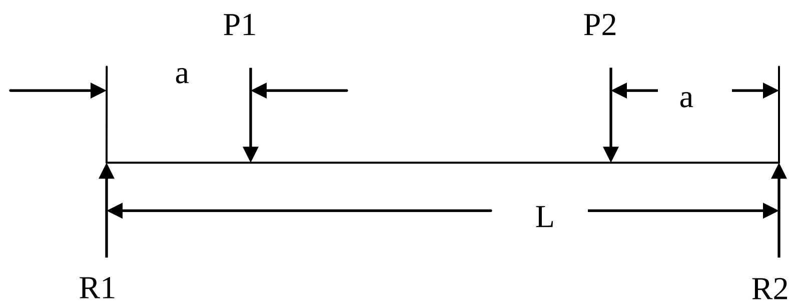

Figure 2. Force distribution diagram of the lifting bracket as it applies vertically

Where: L = 12.50”,

a = (12.5 - 4.50*) / 2 = 4

$P_i = P_1 = P_2$ = 0.5 x 60,000 lbs.= 30,000 lbs.

$R_1 = R_2 = P_i$ = 30,000 lbs.

*. The distance between the lugs for the lifting pin.

So, $M_{max} = P_i\, a$

= 30,000 x 4 (in–lbs)

= 120,000 in-lbs.

In order to find the bending and shear stresses @ the most critical location, it is necessary to find out the geometrical property of the lifting bracket at that location.

Figure 3 is the 2d fabrication drawing of the lifting bracket, the critical area subjected the force P_v should be between two lifting lug, where the properties can be found as: (See drawing MD-407783 for reference)

A_{area} in cross section view, refer to figure 4 on page 5

= (10.0 x 2.50) in^2

= 25 in^2

I_{xx} = (10 x 2.5^3) / 12 (in^4)

= 13 in^4,

S_{xx} = 10.4 in^3

The allowable stresses of the bracket (material ASTM A36)

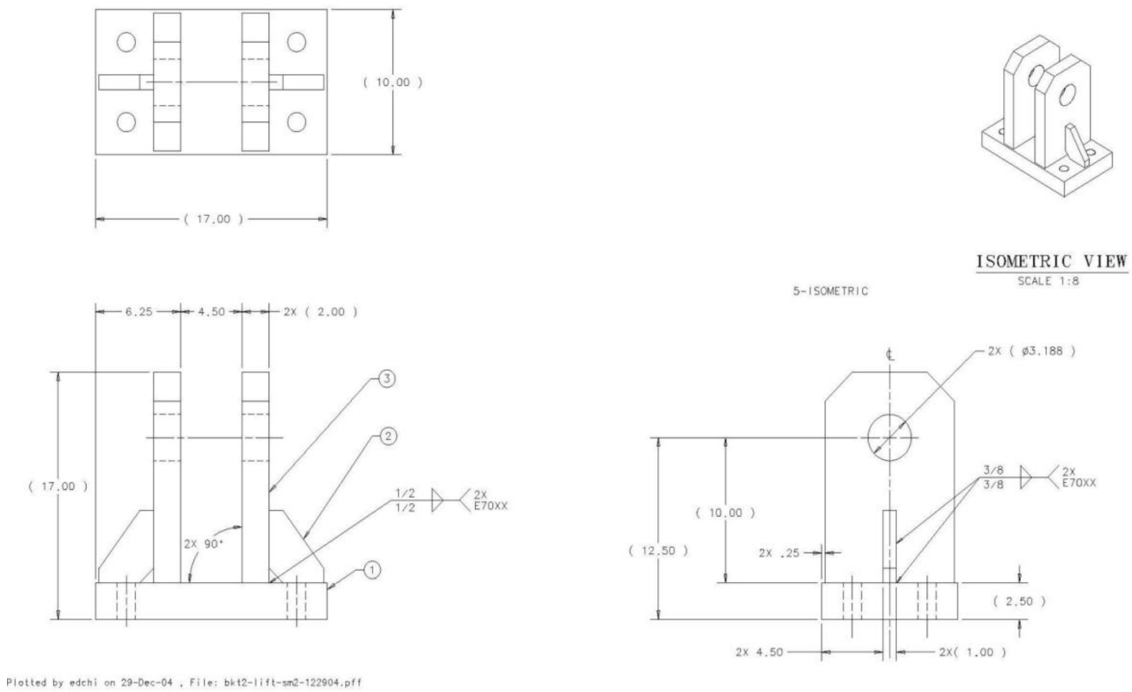

Figure 3. 2D drawing for lifting bracket. (See MD-407783 for details)

$F_b = F_y/3.0 = 12$ ksi $= F_v = F_t$
(per section 20-1.2.2.2, ASME B30.20)

$f_b = M_{max} / S_{xx} = 120{,}000$ in-lbs / 10.4 in^3
$= 11.54$ ksi $< F_b$
$f_v = R1 / A_{area} = 30{,}000$lbs / 25 in^2
$= 1.20$ ksi $< F_v$

The working stresses of the lifting bracket are satisfactory when it is subjected 30 tons force vertically.

2. Find out the working stresses when the lifting bracket is subjected the force P_h which is applying horizontally as shown on figure 4.

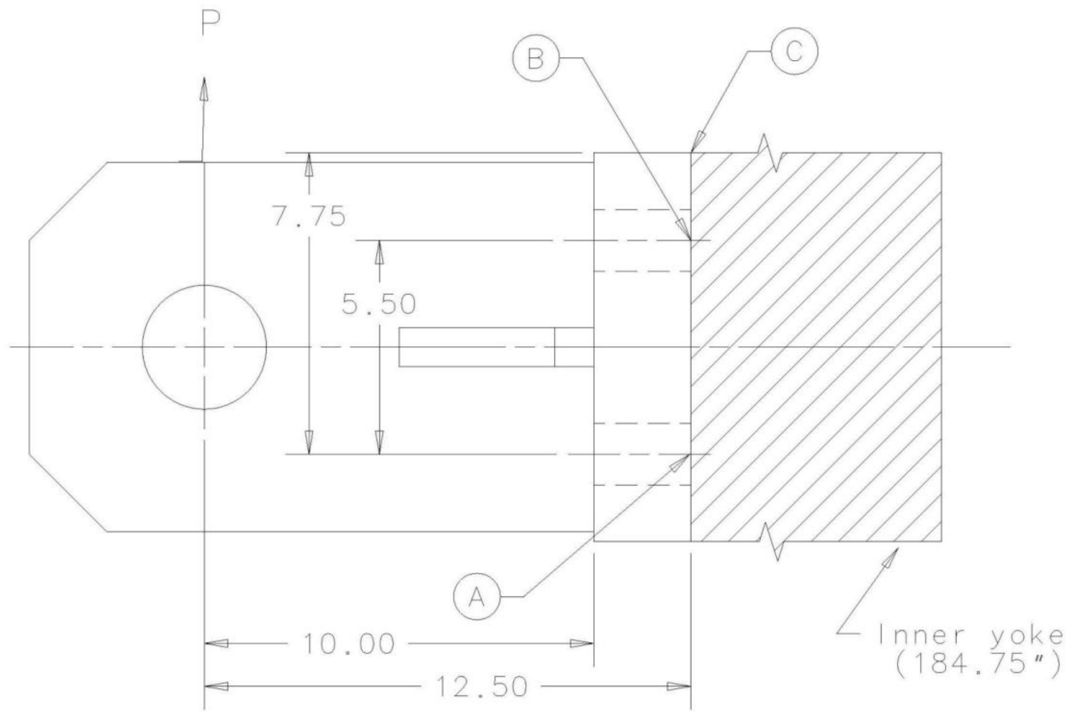

Figure 4. The bracket is subjected the lifting force P_h in 90 degree rotation.

Where $P_h = 0.5 \text{ x } 38 \text{ tons} = 38{,}000 \text{ lbs.}$

2.1. Find the working stresses of the bracket subjected the force P_h as shown on figure 4:

Figure 5 of page 7 is the cross-section view of the lifting bracket at the location of 10" away from the lifting hole, refer to figure 3 and figure 4 for reference.

The geometrical properties (ignore the middle ribs):

$A = (2 \text{ x } 2 \text{ x } 9.5) \text{ in}^2$
$= 38 \text{ in}^2$
$I_{xx} = ((2 \text{ x } 2 \text{ x } 9.5^3) / 12) \text{ in}^4$
$= 285.79 \text{ in}^4$
$S_{xx} = (285.79 \div 4.75) \text{ in}^3$
$= 60 \text{ in}^3$

Moment M_{10} at the location 10" away from the lifting hole:

$M_{10} = (38{,}000 \text{ x } 10) \text{ lbs.-in}$
$= 380{,}000 \text{ lbs-in}$

The working stresses subjected the applying load can be found:

$f_b = M_{10} / S_{xx}$
$= 380,000$ in-lbs $\div 60$ in^3
$= 6.333$ ksi $< F_b = 12$ ksi
$f_v = P / A$
$= 38,000$ lbs $\div 38$ in^2
$= 1.0$ ksi $< F_v = 12$ ksi

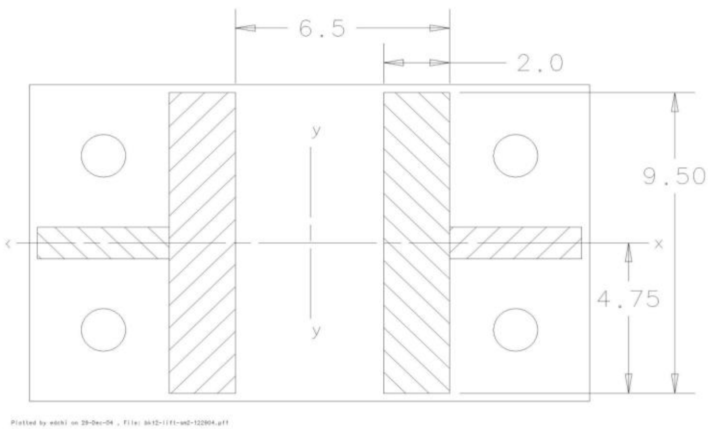

Figure 5. The cross-section view of the lifting bracket at the location of 10" away from the center hole.

The computed working stresses of the bracket are satisfactory per the related codes.

2.2. Compute the working loads of the bolt subjected the applying load $P_{h.}$

The bracket connected with yokes by 4 bolts A and B, and is subjected the applying force P_h as shown on figure 4 of page 6.

Bolt spec: 1 ¼ - 7 (4), ASTM A325 (see drawing MD-407783)
Where: $P_t = 54.0$ kip
(allowable tensional load, per table I-A, part 4, ASD)
$P_v = 20.9$ kip
(allowable shear load, per table I-D, part 4, ASD)

The computed working shear load of the bolt:
$p_v = P_h/4 = 38 \text{ kip} / 4 = \underline{9.5 \text{ kip} < P_v = 20.9 \text{ kip}}$

The computed working tensional load of the bolt:
The moment equation @ location C when the bracket is subjected the lifting force P_h as shown on figure 5:
$\sum M_c = 0 \rightarrow P \times 12.5" - 2 \times (p_{ta} \times 7.75" + p_{tb} \times 2.25") = 0$ (eq. 2.1)

It is reasonable to assume the linear relationship of:

$p_{ta} / p_{tb} = AC / BC = 7.75 / 2.25 = 3/1$

so eq. 2.1 becoming: 38,000 lbs x 12.5 in = 2 x (3 x p_{tb} x 7.75" + p_{tb} x 2.25")

p_{tb} = 475,000 lbs-in ÷ 51 in = $\underline{9.32 \text{ kip} < P_t = 54.0 \text{ kip}}$

p_{ta} = 3 p_{tb} = 9.32 kip x 3 = $\underline{28.0 \text{ kip} < P_t = 54.0 \text{ kip}}$

The computed pull out force P_{out} from the base metal:*

Per eq. 5.3.2.1-1, section 5.3.2.1, part I-A of "Aluminum Design Manual" 6th edition,

$P_{out} = 0.85\, t_b\, D\, F_{tb}$

= 0.85 x 2.0 in x 1.25 in x 26 ksi

= 55.2 kip (per bolt bearing area) > p_{ta} = 28.0 kip

Where: t_b the thread bearing length on base metal (see drawing MD-407832)

D.the nominal dia. of the bolt

F_{tb}. The tensile strength of the base metal, (It is conservatively assumed it is pure iron, where F_t = 26 ksi, see page 798, "Metal Handbook", Vol. I, 8th edition for reference)

The designated bolts are satisfactory when the bracket subject to the special case as it was specified on this section.

3. <u>Weld Calculations:</u>

Figure 6 is the weld configuration for the location where is 10" away from the lifting hole per figure 5 (cross view) and drawing MD-407783.

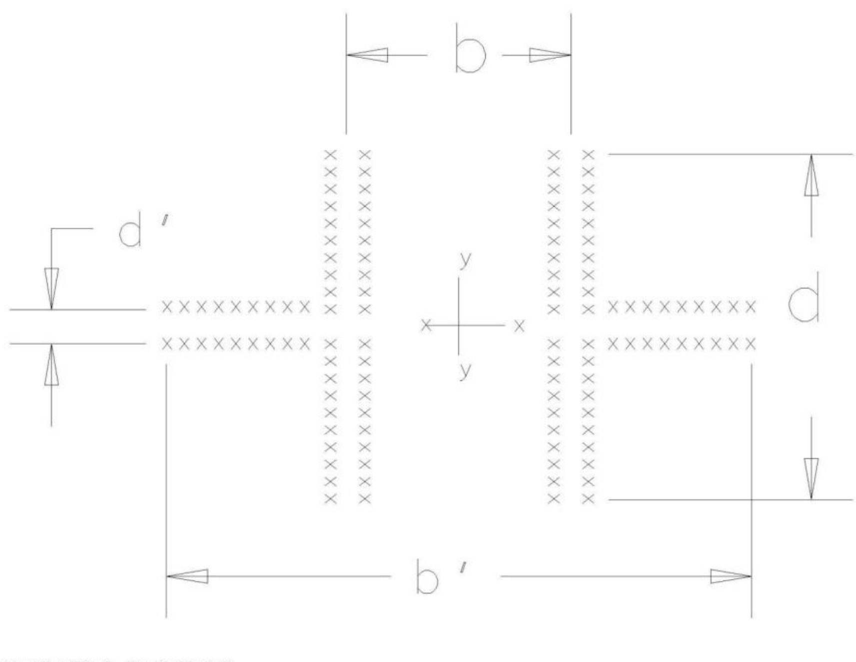

Figure 6. The weld configuration of the bracket @ the location 19" away from the

lifting hole (treat as line with unit thickness).

Find the geometrical properties of the welds as shown on figure 6.

For a simple and conservative approach, ignore the two welding lines with b' & d' dimensions and only consider 4 vertical simulating welding lines.

where d = 9.5 inch, b = 6.5 inch
$L = 4d = 38$ in length of the welds
$I_{xx} = d^3 / 3$
285.79 in^3
$S_{xx} = (2d^2) / 3$
$= 60\ in^2$

The working load per unit length of the weld subject to the applying load can be found:

$f_b = M_{max} / S_{xx}$
$= 380{,}000$ in-lbs ÷ 60 in^2
= 6,333 lbs/in
$f_v = P / L$
= 38,000 lbs ÷ 38 in
= 1,000 lbs/in
$f_r = (f_b^2 + f_v^2)^{½}$
= 6,412 lbs/in

To find the required weld size C:

All weld metals are E70,
Where: $F_u = 70$ ksi
The allowable stresses for the weld metals:
$F_{t2} = F_{v2} = 0.30\ F_u = 21$ ksi

C = combined working load per unit length÷ (effective factor × allowable stress)
= (6,412 lbs/in) ÷ (0.707 x 21 ksi)
= 0.432 in < 0.5 in (designated weld size in the area)

The designated weld size is satisfactory.

Conclusions:
The lifting bracket has been designed per the related engineering codes after the calculations and discussions from several the most critical areas, such discussions were approached by computing the working structural stresses, bolt stresses and weld sizes in terms the different applications.